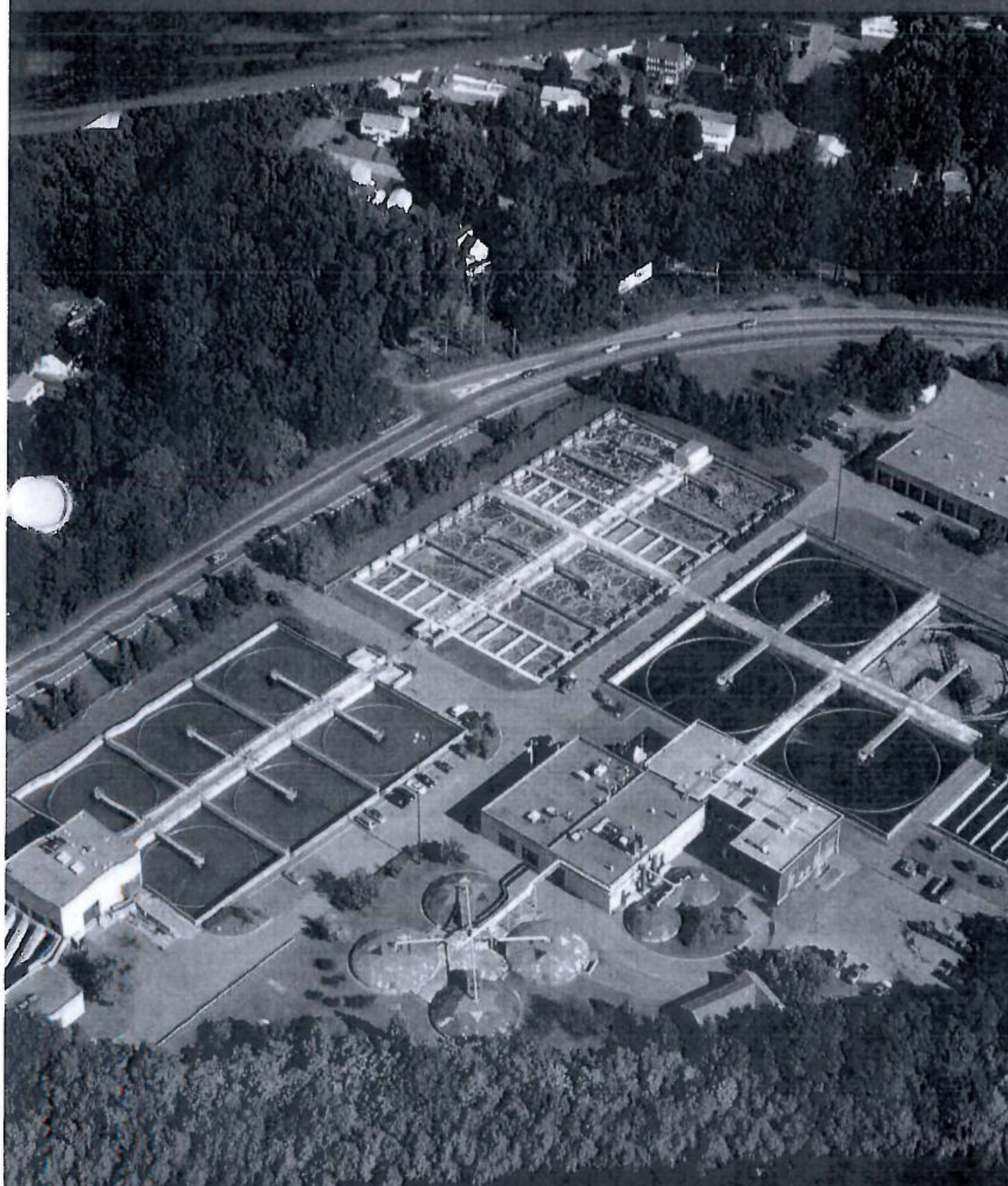
CSO Phase 2
Long-Term Control Plan



Lowell Regional Wastew

Lowell, Massachusetts

August 2014

CDM Smith

LOWELL REGIONAL WASTEWATER UTILITY

WASTEWATER COLLECTION AND TREATMENT

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SUBJECT: CSO Phase 2 Long Term Control Plan (LTCP) for Lowell Massachusetts

DATE: August 15, 2014

Gentlemen:

In conformance with Administrative Order Docket No. 010-026, dated September 30, 2010, and subsequent communication with the Environmental Protection Agency (EPA), the City of Lowell is submitting a Combined Sewer Overflow (CSO) Phase 2 Long Term Control Plan (LTCP) for review and comment.

Before describing Lowell's LCTP, I would like to express my appreciation for the flexibility that your office has afforded the City of Lowell regarding the submittal of this plan. Although the LTCP submission has been delayed, I assure you that the City of Lowell remains dedicated to reducing its CSOs.

To underscore this commitment, the attached submittal describes a program to spend $123M over the next decade, including the immediate investment of $52M in capital improvements that will reduce CSOs, eliminate sewer surcharging, upgrade the combined sewer system, and improve wet-weather treatment capacity at the Duck Island Wastewater Treatment Facility (WWTF). The scope of the CSO Phase 2 LTCP also includes ongoing programs for sewer system monitoring, stormwater management, and sewer rehabilitation. For details of the Phase 2 plan, refer to the attached summary of project scope, schedule, benefits, and budget.

The ongoing programs for sewer rehabilitation and stormwater management are intended to comply with Capacity, Management, Operations, and Maintenance (CMOM) and Municipal Separate Stormwater Sewer System (MS4) requirements. The sewer monitoring program will improve LRWWU's understanding of the Lowell sewer system and refine the existing sewer system model (further discussion below). A Duck Island WWTF peak flow treatment capacity analysis will also be conducted.

The Phase 2 LTCP-CIP program is supported by a $44M capital fund that was authorized by Lowell's City Council on October 13, 2013. In addition, another $9M in funding for sewer rehabilitation and stormwater management programs is secured in the operating budget of the Lowell Regional Wastewater Utility (LRWWU). In addition to a five-year $52M Phase 2 program, LRWWU is proposing a second five-year phase of improvements (CSO Phase 3 LTCP), valued at $71M.

Altogether, Lowell is committed to investing $123M in improvements over the next eleven years, of which approximately $103M is targeted for CMOM and CSO projects. This program is an integrated plan that includes CSO, CMOM, CIP, and MS4 projects. In addition to the benefits listed above, the plan also ensures that important sewage transport and treatment systems continue to function properly. Without reliable routine operations, high flow management is not possible.

A review of the Phase 2 program reveals many of the same projects that were previously proposed as part of a "LTCP 1A" plan. Unfortunately, a delay in funding caused the deferral of those projects to this newly-proposed Phase 2 program, which is now fully funded. The new program includes several well-defined projects, with one caveat: the Pevey Street wet-weather storage project, whose funding is dependent upon the cost to implement the remainder of the Phase 2 program. If necessary, this project will be deferred to the Phase 3 program.

The proposed Phase 3 projects need further refinement. In order to better define these projects, LRWWU must first address the following deficiencies: 1) gain a better understanding of the Lowell sewer collection system in key locations; 2) consistently achieve peak flow treatment capacity at the Duck Island WWTF; and 3) realize the benefits of a one-million gallon interceptor storage project at Read Station.

In order to improve its understanding of transport and treatment capacities, LRWWU is ready to embark on a sewer system monitoring program and a capacity analysis of the Duck Island WWTF. These assessments will occur concurrently, along with peak flow improvements at Duck Island and the installation of flow control gates at Read Station. The importance of achieving consistent peak flow treatment at Duck Island and enabling interceptor storage at Read Station cannot be over-stated.

LRWWU acknowledges that maximizing wet-weather treatment capacity and interceptor storage have been long-standing objectives. Significant improvements have been made to the Duck Island facility, but two crucial upgrades must be completed to support reliable wet-weather treatment. Frequent failure of the plant's original clarifiers (six primary and four secondary) limit LRWWU's ability to treat peak flows. Compounding this limitation is an unreliable sludge de-watering system (twenty-year old belt filter press) that results in high secondary blankets, which further limit peak flow treatment.

Interceptor storage has been optimized in every location except Read Station. This cost-effective approach to wet-weather storage has been utilized with great success at Warren, Merrimack, Tilden, West, Walker, and Beaver Brook stations. Unlike the other stations, Read Station was not originally built with flow control gates. During the Phase 2 LTCP program, LRWWU will install gates and realize the benefit of nearly one million gallons of available wet-weather storage that is currently not utilized.

With the completion of clarifier replacements and the installation of new centrifuges, and the additional storage at Read Station, LRWWU will be capable of achieving consistent peak flow treatment and maximizing interceptor storage. Once the capacity of its existing facilities is fully maximized, LRWWU will be able to finalize its CSO Phase 3 LTCP projects. In order to accommodate a thoughtful assessment of the benefits of Phase 2 improvements, LRWWU is inserting a one-year assessment period between the two LTCP phases. With this framework in mind, we propose the submittal of another five-year plan in December 2019.

The Phase 3 LTCP will feature at least one large-scale wet-weather storage project and the construction of a 60-MGD wet-weather treatment facility at Read Station. The second phase of improvements at Read Station will increase LRWWU's overall wet-weather treatment capacity significantly, by as much as 60%. We expect this increased capacity to drastically reduce CSOs on the North Bank of the Merrimack River, and to determine the scale of work necessary to do the same on the river's South Bank.

The Read Station wet-weather treatment facility will be a "game-changer", which is why LRWWU is proposing a re-evaluation of its long-term control plan in 2024, after this milestone is attained. LRWWU's proposal of two five-year plans with a one-year assessment period demonstrates our belief in an adaptive management approach to CSO reduction. This is the same approach that LRWWU successfully implemented in its Phase 1 program, an approach that afforded us the flexibility to phase projects and adapt their scope as our understanding grew and progress was made. The ability to re-prioritize and revise projects proved to be invaluable; and we expect the same benefits to accrue during the next ten years of Phase 2 and Phase 3 projects.

LRWWU acknowledges that the current plan varies from a typical long-term control plan, in terms of duration and its reluctance to rely on long-term predictive modeling during high-flow conditions. Nevertheless, our dedication to reducing CSOs is evident in our proposed $123M plan. Given our current level of understanding and the under-utilization of our existing facilities for wet-weather storage and treatment, we believe it would be premature to provide a plan with a longer duration.

Although our current sewer system model could be used to predict sizing and costs of future projects, we believe that developing a long-term capital plan based on this model would be an unsound approach. The reality is that LRWWU does not trust the current model, which is why we are proposing to revise the model with additional monitoring. An important technique that we intend to use is calibration of the existing model by measuring actual levels in key locations during high-flow conditions.

LRWWU has had excellent success characterizing its interceptor system using level monitoring (rather than flow metering). We believe that accurate open-channel flow measurement, particularly in temporary configurations, is very difficult to achieve. Level measurement, on the other hand, is a much more reliable basis for system characterization. With this approach in mind, LRWWU utilized a level monitoring program in 2007-2008 that informed its High Flow Management Program. This program has been a major factor in LRWWU's remarkable success reducing CSOs by 80% in the past decade.

A good example of LRRWU's mistrust of the existing system model and our insufficient understanding of the sewer system exists in the Marginal-Pevey-Middlesex Sewer corridor. This undersized sewer line is prone to severe surcharging during heavy rainfall, because two CSO outfalls were capped twenty-five years ago with no accommodation made for excess flow. Surcharging in this line has been a serious public health concern since that time, which is why LRWWU has included the following two projects in our Phase 2 program: the Marginal Sewer Relief Pipe and the Middlesex Sewer Relief Pipe.

We know that these projects will alleviate surcharging in the Marginal-Pevey-Middlesex sewer line. What is uncertain is whether these improvements will eliminate the existing surcharge conditions. LRRWU believes that level monitoring in this sewer and an evaluation of the actual (not predicted) benefit of the above two projects will inform our decision regarding the need for subsequent improvements. LRWWU is considering storage and conveyance solutions at 91 Pevey Street that require more information and a better understanding in order to be properly sized and supported with adequate budget.

In ten years, when the capacity of the existing facilities is fully utilized and the new wet-weather treatment facility has been completed at Read Station, LRWWU will be in a solid position to determine the next steps in its CSO long-term control plan (CSO Phase 4 LTCP). With two treatment facilities on the Merrimack River's North Bank, it is a certainty that future projects will include increased conveyance to downstream facilities at Read Station and the Duck Island WWTF. The first conveyance project is proposed in Phase 3, with additional siphons at Beaver Brook constructed to alleviate CSOs at this station and fully utilize the treatment capacity of the Read Station wet-weather facility.

In preparation for Phase 4, LRWWU will evaluate the feasibility of adding new siphons across the Merrimack and Concord rivers. These new siphons would alleviate CSOs associated with Warren and Merrimack-Barasford stations. In order to accommodate the increased peak flows from upstream, expansion of the Duck Island facility is also being considered. These projects will be further evaluated after the benefits of the Phase 2 and Phase 3 programs are realized.

In the meantime, I am seeking your support for LRWWU's $123M plan to reduce CSOs and sewer surcharging in the City of Lowell during the next ten years. I welcome your feedback and ask that we continue our collaborative approach to improving water quality in the Merrimack River watershed.

Should you have any questions, please do not hesitate to call me at 978-674-1601.

Respectfully,

Mark A. Young

Mark A. Young
Executive Director
Lowell Regional Wastewater Utility

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Contents

Appendices

List of Tables

List of Figures

Section 1
Introduction

1.1 Background

1.1.1 General

The Lowell Regional Wastewater Utility (LRWWU), acting through the city of Lowell, Massachusetts, owns and operates a combined sewer system that serves the city and neighboring communities. Well into the 20th century, combined sewer systems were a nationally accepted engineering standard for the conveyance of sewer and stormwater flow in older, urban communities in the United States. Dual-purpose (sewer and stormwater) conveyance pipes were installed to discharge the combined flow into the closest receiving water. This approach was considered an efficient design that would result in more manageable and cost effective collection systems.

Later, the 1972 Clean Water Act (CWA) required cities to provide treatment of their sewer flow; interceptor pipes were constructed to collect the sewerage and convey it to treatment facilities. The interceptor and treatment systems were designed to convey dry weather flow and a portion of the stormwater flow. The interceptors were also constructed with regulators, or permitted discharge outfalls, to provide hydraulic relief and protection of infrastructure. Wet weather flow in excess of the interceptor conveyance pipe capacity were designed to be discharged, at these permitted discharge outfalls, to the receiving water bodies as combined sewer overflows (CSOs).

More recently, federal regulations have been strengthened, requiring communities like Lowell to improve receiving water quality by reducing untreated CSO discharges. Lowell has nine locations where untreated CSOs discharge from the combined sewer system into Beaver Brook and the Merrimack and Concord Rivers. LRWWU has been working diligently since the 1990s to plan, design, and implement system improvements to reduce its CSO discharges. Over the last ten years, LRWWU has reduced the total volume of annual average CSO discharges by about 80 percent (approximately 800 million gallons of CSO per year) at a cost of about $120 million by implementing system capital improvements recommended in the Phase I CSO Long-Term Control Plan (2002).

This report summarizes the work completed by the city to date and evaluates the alternatives and presents a future phased implementation program to continue to advance CSO reduction in Lowell.

1.1.2 Regulatory Requirements

There are several competing federal and state regulatory standards that must be met by the city of Lowell relating to its combined sewer, sanitary sewer, and storm drainage systems.

In 1994, the United State Environmental Protection Agency (USEPA) issued the National Combined Sewer Overflow (CSO) Control Policy, which is administered through the National Pollutant Discharge Elimination System (NPDES) permits program under the provisions of the CWA. This Policy establishes a comprehensive national strategy to ensure that municipalities, permitting authorities, water quality standards authorities, and the public engage in a coordinated planning effort to develop and implement cost-effective CSO controls that ultimately meet appropriate environmental and health objectives. The Policy is mandated that each CSO community develop and implement a Long-Term Control Plan (LTCP) to eliminate or reduce untreated CSO discharges to the nation's waterways.

The Massachusetts Department of Environmental Protection (MADEP) established its own CSO Policy in 1997 reflecting the minimum requirements of the USEPA CSO Policy and identification of specific State Water Quality Standards with respect to CSOs.

The federal and state CSO policies and standards represent the most immediate regulatory requirement. There are also new regulations concerning the quality and discharge of stormwater that were promulgated by the USEPA in 1999. Under the stormwater regulations, the city must comply with the conditions of a 2003 General Stormwater Permit for the state of Massachusetts as a municipal separate storm sewer system (MS4). Compliance requirements under future revisions for the general stormwater permit will likely affect the City's final selection of CSO abatement alternatives. In addition, operations of the sanitary sewer collection system are governed by the requirements of USEPA's Capacity Maintenance Operations and Management program (CMOM), which is designed to minimize Sanitary Sewer Overflows (SSOs).

Compliance with the CSO, SSO/CMOM, and Stormwater Rule policies is enforced through the NPDES permit program under the provisions of the CWA. Lowell's NPDES permit (Permit No. MA0100447) was reissued to the city on September 2005 and expired on September 2010.

In 2012, the USEPA released a memo entitled "Integrated Municipal Stormwater and Wastewater Planning Approach Framework." This memo outlines a new policy by the regulator agency to allow communities to holistically evaluate both stormwater and wastewater regulatory compliance and water quality objectives to develop implementation plans that balance these objectives.

1.1.3 Lowell's CSO Compliance History

On November 10, 1988, the City of Lowell entered into a Consent Order Judgment with the USEPA regarding the evaluation and implementation of sewer system improvements to address infiltration/inflow, combined sewer overflows, and operational issues at the wastewater treatment plant (WWTP).

LRWWU completed improvements at the WWTP to address operations, and submitted two separate reports in 1990 on infiltration/inflow in the sewer system (Phase I Infiltration/Inflow Investigations Final Report, Camp Dresser & McKee Inc., CDM) and combined sewer overflows (CSO Facilities Plan, CDM). Negotiations between the state, USEPA, and the city on the recommended CSO Plan continued until early 1991, when significant fiscal constraints and adverse economic conditions caused the stakeholders to delay the development of a final recommended CSO facility plan.

In November 1994, at the request of USEPA, the City provided a summary of its CSO abatement/control activities (since 1990) along with a description of the City's ongoing best management practices. This update provided the EPA with a statement of progress toward compliance with the 1994 CSO Policy.

In June 1997, the EPA requested that the City of Lowell initiate an update of its 1990 CSO Facilities Plan to incorporate the new federal and state regulatory standards and policies, to revise the existing computer model, and to evaluate alternatives for current flow conditions. To address the new regulatory requirements, LRWWU and CDM Smith developed a phased CSO Facilities Planning Approach that complied with the 1994 USEPA National CSO Policy and the 1997 MADEP CSO Policy.

The CSO approach undertaken by LRWWU was designed to allow for the systematic evaluation of the changes that have occurred in Lowell's collection system since the completion of the last study and consider new alternatives to address the city's current CSO discharges. This approach was approved and an implementation schedule was established in a MADEP letter dated November 19, 1998.

As part of the late 1990s work, LRWWU's CSO work comprised the completion of a series of reports and programs, and the design and construction of new system improvements including:

- Long-Term Flow Monitoring Plan (February 1998)
- Nine Minimum Control Measures Report (April 1998)
- Conceptual Sewer Separation Plan for Key Drainage Areas (June 1998)
- Varnum Avenue Capacity Assessment (December 1998)
- Smoke Testing Program Report (September 1999)
- WWTP Capacity Analysis (January 2000)
- Preliminary Design Report on Humphrey's Brook Sewer Separation (January 2000)
- CSO and Stormwater Sampling Program Results (April 2000)
- Draft LTCP/DEIR Scope of Work (July 1999)
- WWTP Improvements Preliminary Design (April 2001)

These reports provide discrete assessment of the existing combined sewer and treatment system in Lowell. The report findings and conclusions were used to develop potential alternatives for CSO abatement, which were first reported in the draft Long-Term Control Plan presented in 2001, and then updated in the Revised Long-Term Control Plan that was completed in February 2002 (CDM).

Based on the recommendations proposed in the 2002 Revised LTCP, LRWWU implemented its Phase I LTCP Plan at a cost of about $120 million, which included:

- sewer separation of more than 1,000 acres of combined sewer area (a reduction of 20 percent of the combined sewer area);

- about $50 million of wastewater treatment facility improvements to completely overhaul major processes and equipment at the plant;

- CSO diversion structure improvements to address aging equipment, safety hazards, operational issues, and to install new flow control gates, flow monitoring equipment, and remote control instrumentation to optimize the use of the interceptor for in-line storage of wet weather flow; and

- Development and implementation of a comprehensive high flow management plan to use existing infrastructure to reduce CSO discharges.

Section 3 provides a summary of the Phase I Plan improvements and the CSO reduction benefits achieved by the program.

1.2 Purpose

The purpose of this report is to update LRWWU's LTCP for CSO abatement as required by the USEPA Administrative Order No. 010-026 (dated September 30, 2010, attached in Appendix A), to document the effectiveness of Phase I CSO controls and improvements, to characterize and document specifics of the existing combined and separated collection systems, to evaluate CSO impacts to Beaver Brook and the Concord and Merrimack Rivers, and to establish an approach to address the remaining CSOs.

1.3 Project Approach

The Phase 2 scope of work included the following general tasks:

- Perform flow monitoring in the spring and summer of 2012 to better characterize existing collection system flows;
- Update the existing Stormwater Management Model (SWMM) to Version 5.0 and include recent modifications made to the collection system from the Phase I improvements. Also include model updates and expansions as necessary to document existing conditions as verified from the sewer system inspections;
- Identify frequency of CSOs expected in a typical year after implementation of Phase I;
- Characterize the impacts of the remaining CSOs in a typical year;
- Evaluate the benefits achieved by the Phase I LTCP Program;
- Develop and evaluate alternatives to address LRWWU's priorities in the combined sewer system to reduce CSO reduction and sewer system surcharging; and
- Develop an integrated implementation plan based on LRWWU's preferred alternatives to address the remaining CSOs.

1.4 Report Organization

This Phase 2 LTCP report is organized into nine sections as follows:

- Section 1 – Provides an introduction to the history and purpose of this study;
- Section 2 – Describes the existing collection system, pump stations and WWTF;
- Section 3 – Presents the planning and system improvements that have been completed in the Phase I LTCP Program and the benefits achieved by the program;
- Section 4 – Describes the re-development of the stormwater management model (SWMM) and the existing and future baseline conditions of the combined sewer system for various design storms;
- Section 5 – Evaluates water quality impacts related to Lowell CSOs;
- Section 6 – Examines available CSO abatement technologies and determines those best applicable for development of LRWWU's CSO control alternatives; and
- Section 7 – Presents LRWWU's recommended approach to continue progress on its CSO reduction goals integrated with CIP priorities and annual expenditures to comply with other regulatory requirements.

Section 2

Existing System

2.1 General

LRWWU owns and operates the wastewater collection and stormwater drainage systems within the city's corporate boundary. LRWWU also collects and provides treatment to sewer flow from five neighboring communities (Billerica, Chelmsford, Dracut, Tewksbury, and Tyngsborough).

A significant portion of Lowell's wastewater collection system was constructed in the early 1900's as the mill city developed. Many of these older parts of the system, found in the central area of the city, were originally constructed and still exist today as a combined sewer system. Combined wastewater is conveyed to the regional wastewater treatment facility at Duck Island (Duck Island WWTF) for treatment prior to discharge to the Merrimack River. Excess wet weather flow collected by the combined sewer system is discharged to the Merrimack and Concord Rivers and Beaver Brook as CSOs. There are nine CSO diversion stations and outfalls in Lowell's combined sewer system.

LRWWU has made substantial improvements to its combined sewer system since 2005, including Duck Island WWTF capacity and process improvements, rehabilitation of the sewer system, installation of new drains for separation of the combined system, and capital and operational improvements to the CSO diversion stations to enhance control of the system during wet weather conditions. These system improvements are discussed in Section 3.

The wastewater collection and drainage systems are operated in compliance with the Nine Minimum Control Measures, Phase II Stormwater General Permit, and Capacity and Maintenance Plan program requirements.

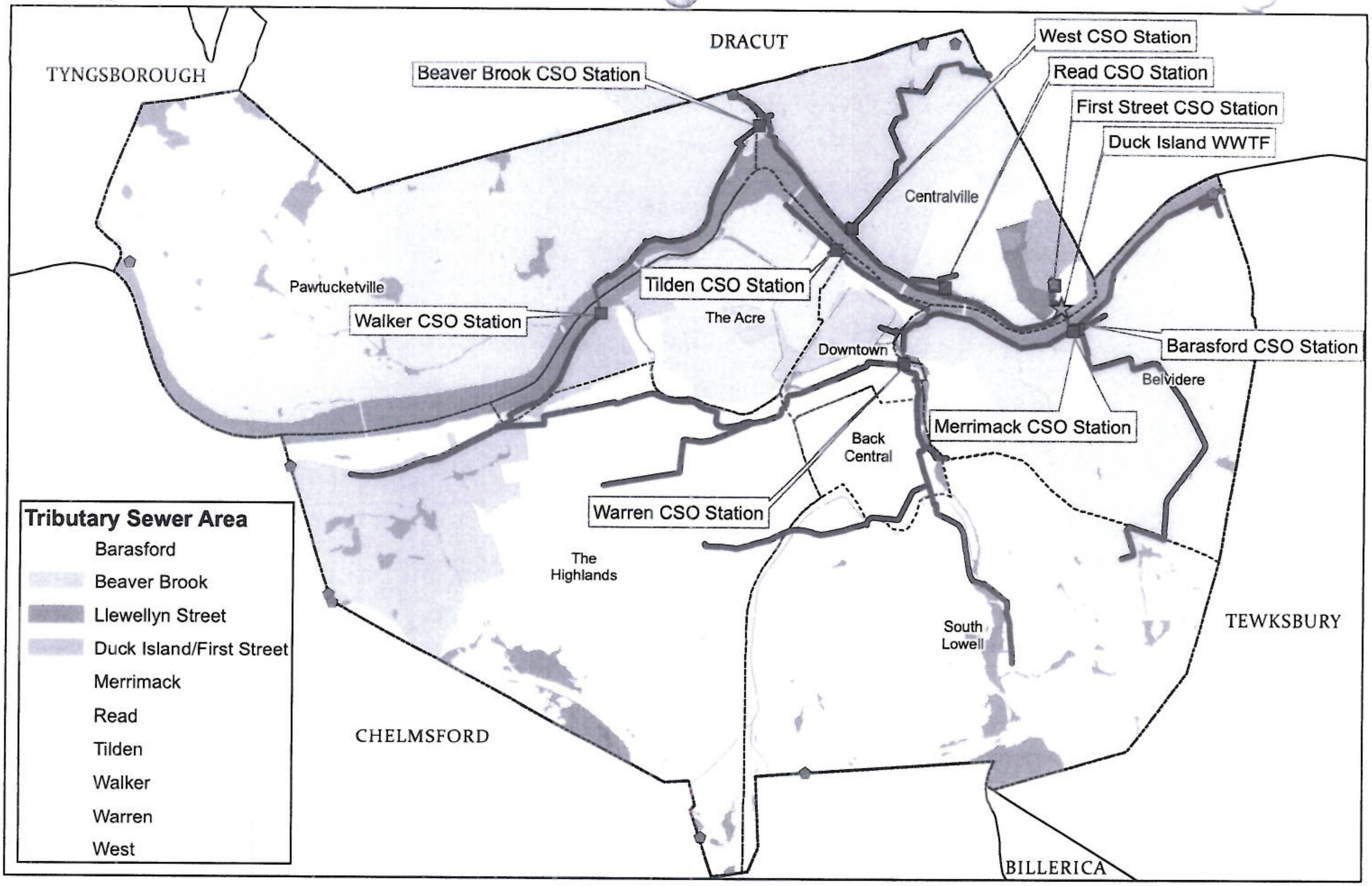
2.2 Wastewater Collection System

The city is bisected by the Merrimack River, with the WWTF located on the eastern side of the city at the Dracut border, as shown in Figure 2-1. The interceptor piping system, which was designed to collect the flow from the older combined sewers that used to discharge directly into the rivers, is generally located along the west riverbank of the Concord River and the north and south river banks of the Merrimack River. Flow is conveyed from west to east to the WWTF. The interceptor system has multiple river crossings (many of them siphons) that are used to convey the flow across Beaver Brook and the two rivers.

2.2.1 Sewer Service Area

Lowell's wastewater collection system serves nearly 100 percent of the population and developed land area within the LRWWU. A small number of septic systems still serve some individual buildings, primarily in the northwestern part of Lowell. These buildings are gradually being connected to the collection system.

Approximately 90 percent (7600 acres) of the total land area of the city is served by the wastewater collection system.



CDM Smith

Lowell, Massachusetts
CSO Phase 2 LTCP

Figure 2-1
CSO Tributary Sewer Area

Figure 2-1 shows the sewer tributary areas to each CSO diversion station in the city. Generally, the wastewater collection piping system conveys flow north or south to the Merrimack River, where it is collected by larger sewer interceptor pipes along the river banks. In the Highlands and South Lowell neighborhoods, flow is generally conveyed east toward the Concord River, where is it collected by the Warren Interceptor located along the banks of the Concord River. Generally, all flow into the interceptor is eventually regulated by a CSO diversion station at least once, except for one direct sewer connection at Llewellyn Street. Table 2-1 summarizes the piping and sewer area characteristics of each CSO tributary area.

Lowell's wastewater collection system and regional WWTF also serve the adjacent communities of Chelmsford, Dracut, Tewksbury and Tyngsboro, Massachusetts. These communities operate and maintain separate sanitary wastewater collection systems. Thus, these systems were not evaluated as part of this study.

Flows from the outside communities enter Lowell at a number of points at the corporate boundary and are conveyed by the LRWWU's interceptor and collection system to WWTF. The primary metering locations used to measure these regional flows are shown on Figure 2-1 ; There are some small areas with direct connections of outside community flow that are unmetered; however these flows are estimated for billing purposes by alternate methods.

2.2.2 Combined Sewer Area

Figure 2-2 shows the major interceptor/collection system facilities and identifies the remaining combined sewer area tributary to each CSO diversion station and outfall. Approximately 56 percent of the land area served by the wastewater collection system (3600 acres) is served by combined sewers. Combined sewer systems are primarily located in the central and eastern portions of the city, primarily in the downtown area. Service areas with separate sanitary and storm water conveyance systems are located in the western and southern portions of the city.

Generally, combined flow in most areas of the areas of the system is conveyed to at least one downstream CSO regulator where excess flow can be discharged as CSO if there is no downstream capacity in the interceptor system There is one small combined sewer area (Llewellyn Street), labeled as Duck Island on Figure 2-2, connecting to the Duck Island Interceptor that is not controlled by a CSO regulator.

There are also several large areas where surface flow from separated areas in Dracut enter the combined sewer collection system, as shown in Figure 2-1. The largest area is tributary to Humphreys' Brook, which enters the sewer system at Humphrey's Street. Two other areas are Billings Street and Hovey Field. These are discussed in Section 2.5.4.

Stormwater runoff into the combined sewer system is generated by precipitation over pervious and impervious areas. Pervious areas, such as grassed areas or fields, do not have significant runoff during storm events as rainfall generally infiltrates into the soil until the ground is saturated. Accordingly, peak flow into the combined sewer from pervious areas is dampened. However, impervious areas, such as roofs and paved roads and parking lots, contribute significantly to peak flow rates in the combined sewer system as precipitation generally will run off this land area immediately and enter the sewer system via local catch basins.

Table 2-1
Characteristics of Subareas

CSO BASIN	Combined Sewer Area (Ac)	Separated Area (Ac)	Total Area (Ac)	Combined Sewer (LF)	Separated Sewer (LF)	Total System (LF)
Walker	109	333	442	18,664	22,061	40,725
Beaver	343	1,198	1,540	66,835	127,178	194,013
West	533	5	538	97,527	5,166	102,692
Read	173	13	186	34,509	3,483	37,993
First	50	49	98	11,039	4,730	15,770
Tilden	266	134	400	66,602	14,376	80,979
Warren	1,242	1,904	3,146	239,692	257,431	497,123
Merrimack	365	56	420	70,801	12,267	83,068
Barasford	543	243	786	89,427	16,081	105,508

Table 2-2 shows a breakdown of pervious versus impervious area of each combined sewer area based on the city's GIS. Table 2-2 also shows a breakdown of the type of impervious area within each combined sewer area including city roads, other paved areas (such as parking lots and driveways), flat roofs and sloped roofs. If LRWWU were to consider adding green infrastructure or low impact development practices (LID) as opportunities to control CSO discharges, these system improvements could be used to control runoff from some impervious areas in the combined sewer system. Generally, LID stormwater controls could be applied to flat roofs and other paved areas (not including city roads). LRWWU is already familiar with some LID practices having implemented pervious pavements, green roofs, and retention areas at the WWTF. These impervious area types system wide total about 800 acres or about 22 percent of the total combined sewer area tributary to the CSO stations.

In addition, LRWWU could consider further application of green infrastructure such as a "Green Streets" program that will also provide further reduction along city roads.

2.2.3 Collection Piping System

There are approximately 220 miles of gravity sewer pipe, ranging in size from 4 to 120 inches in diameter. Most of the sewer pipes in Lowell are circular but a number of the larger collector pipes in Lowell's system are irregular-shaped (i.e. egg-shaped) pipes. Most of the smaller sized pipelines are constructed of vitrified clay with the larger sized pipelines being of brick and mortar construction. Pipelines installed more recently are constructed of concrete or PVC.

There are approximately 5,900 sewer manholes in the wastewater collection system. Most of the manholes are constructed of brick and mortar; manholes installed more recently are precast stations made of concrete.

LRWWU has performed extensive sewer system rehabilitation over the last decade as part of its sewer separation program and its annual I/I reduction program, which was partially targeting some of these past high priority I/I areas. This work is discussed in Section 3.

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Table 2-2
Breakdown of Impervious Area

CSO Basin	Total Acreage	Combined Sewer Area (acres)	Combined Sewer System Area				Breakdown of Impervious Area within Combined Sewer Area (acres)								
								Breakdown of Buildings							
								Flat Roofs		Peaked Roofs		City Roads		Other Paved Areas	
			Pervious Area (Acres)	Percent Pervious	Impervious Area (Acres)	Percent Impervious	Total Building Area	Area	Percent	Area	Percent	Area	Percent	Area	Percent
Beaver Brook	1,776	403	208	52%	195	48%	99	1	1%	98	50%	87	45%	9	4%
First	49	49	37	76%	12	24%	4	0	0%	4	33%	5	44%	3	23%
Read	174	174	73	42%	101	58%	30	1	1%	29	29%	37	36%	34	34%
Duck Island	84	40	30	76%	10	24%	2	1	10%	1	10%	5	54%	2	25%
Barasford	774	570	334	59%	236	41%	67	3	1%	64	27%	69	29%	100	42%
Merrimack	483	392	167	43%	225	57%	76	21	9%	55	24%	62	28%	87	38%
Warren	3,003	1,063	412	39%	651	61%	226	31	5%	195	30%	161	25%	264	41%
Tilden	367	268	69	26%	199	74%	61	10	5%	51	26%	49	24%	89	45%
Walker	576	124	53	43%	70	57%	20	8	11%	12	17%	16	22%	35	49%
West	564	564	281	50%	283	50%	99	9	3%	90	32%	83	29%	101	36%
Total	7,850	3,646	1,664	46%	1,982	54%	684	85	2%	599	16%	574	16%	724	20%

2.2.4 Interceptor Piping Network

Although the combined sewer system has been in service since the early 1900's (and is more than 100 years old), most of the interceptor system, located along the banks of the Merrimack and Concord Rivers, was constructed in the 1970s to intercept and convey flow to the WWTF. The interceptors were all designed to convey dry weather flow and a portion of the wet weather flow to the WWTF.

There are eleven main interceptors in the Lowell wastewater collection system. These interceptors are generally referenced based on the name of the downstream CSO station or facility with the exception of the Marginal/Middlesex Interceptor, which contributes flow to the Warren CSO Station. The interceptors are listed in Table 2-3.

Figure 2-3 shows a schematic of the interceptor network. A further description of the interceptor piping system and routes is presented below. The CSO diversion stations are discussed further in Section 2.2.5.

Table 2-3 Summary of Interceptor Piping Network

Interceptor	Length of Pipe	Range of Diameters (inches)
West/North Bank Interceptor System		
Walker Interceptor	9,850 Feet	30 to 48
Beaver Brook Interceptor	6,800 Feet	30 to 48
West Interceptor	5,050 Feet	30 to 48
Read Interceptor	3,280 Feet	96
Duck Island Interceptor	3,475 Feet	96
South Bank Interceptor System		
Upper Tilden Interceptor	2,765 Feet	42 to 72
Lower Tilden Interceptor	2,930 Feet	36
Marginal/Middlesex Interceptor	12,200 feet	36 to 52- by 35- egg shaped
Warren Interceptor	2,975 Feet	84 to 90
Merrimack West Interceptor	5,335 Feet	72 to 120
Merrimack East Interceptor	5,465 Feet	48 to 120
Barasford Interceptor	10,200 Feet	24 to 60

Walker Interceptor

The Walker Interceptor begins at the Lowell/North Chelmsford boundary and runs east along the south bank of the Merrimack River to the Walker Street CSO Diversion Structure. The profile of the interceptor is shown in Figure 2-4. This interceptor consists of approximately 9,850 linear feet of reinforced concrete pipe, ranging in size from 30 to 48 inches in diameter. The Walker Interceptor collects combined wastewater flow from several small branches of the collection system in the southeast area of Lowell and sanitary flow from the North Chelmsford regional connection. Wastewater flow from the Walker Interceptor is conveyed to the Beaver Brook Interceptor, under the Merrimack River, via three siphons (14, 16, and 20 inches in diameter for a total capacity of approximately 8 MGD) located within the Walker CSO structure.

The Walker CSO Station regulates the amount of wet weather wastewater flow conveyed to the Beaver Brook Interceptor by the siphons. All dry weather flow passes through the structure for conveyance to the WWTF.

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Beaver Brook Interceptor

The Beaver Brook Interceptor begins at the siphon outlet structure across the Merrimack River from the Walker CSO Station and runs east along the north bank of the Merrimack River to the Beaver Brook CSO Station.

The profile of the interceptor is shown in Figure 2-5. This interceptor consists of approximately 6,800 linear feet of reinforced concrete pipe, ranging in size from 36 to 96 inches in diameter. The Beaver Brook Interceptor collects combined wastewater flow from the northwest portions of Lowell collection system on the north side of the Merrimack River in addition to flow collected and conveyed by the Walker Interceptor. Wastewater flow conveyed by this interceptor is regulated by the Beaver Brook CSO Station. Flow passing through the Beaver Brook CSO Station is conveyed by a set of siphons (16-, 20-, and 24-inches in diameter for a total capacity of approximately 25 MGD) across Beaver Brook to the West Interceptor. Excess wet weather flow can be discharged to Beaver Brook.

West Interceptor

The West Interceptor begins at the Dracut town line and runs south along Beaver Brook and east along the north bank of the Merrimack River to West CSO Station along VFW Highway near West Street. The interceptor collects sanitary flow from one of major regional sewer connection from Dracut. The West Interceptor also receives flow from the Beaver Brook Station via the siphons under Beaver Brook.

The profile of the interceptor is shown in Figure 2-6. The interceptor consists of approximately 5,050 linear feet of reinforced concrete pipe, ranging in size from 48 to 96 inches in diameter.

The West CSO Station regulates the amount of wet weather wastewater flow conveyed downstream. The West CSO station is the last regulating structure along the West/North Bank Interceptor system before the flow enters the Duck Island WWTF. Excess wet weather flow can be discharged to the Merrimack River from the West Station.

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Merrimack West Interceptor

The Merrimack West Interceptor begins at the siphon outlet structure from Warren CSO Station and runs north along the east bank of Concord River. From the confluence of the Concord River, the Merrimack West Interceptor runs east along the south bank of the Merrimack River to the Merrimack River CSO Station. The Merrimack West Interceptor accepts flow from the Warren siphon outlet structure, a siphon outlet structure at East Merrimack Street, and the Lower Tilden Interceptor siphon outlet at the confluence of the Concord River.

The profile of this interceptor is shown in Figure 2-11. The interceptor consists of approximately 5,335 linear feet of reinforced concrete pipe, ranging in size from 72 to 120 inches in diameter.

Dry weather flow and a portion of wet weather flow collected by the Merrimack West Interceptor is conveyed across the Merrimack River to the WWTF by a set of siphons (30-, 36-, and 48-inches in diameter) at the Merrimack CSO Station. Excess wet weather flow is diverted to the Merrimack River at this location.

Merrimack East Interceptor

The Merrimack East Interceptor begins at the Lowell/Tewksbury boundary and runs west along the south bank of the Merrimack River CSO Diversion Structure. This interceptor collects combined wastewater flow from several sewer tributary areas of the wastewater collection system adjacent to the southeastern bank of the Merrimack River and sanitary flow from the Tewksbury regional connection. The Barasford CSO Station discharges flow into this interceptor directly adjacent to the Merrimack CSO Station.

The profile of this interceptor is shown in Figure 2-12. The interceptor consists of approximately 5,465 linear feet of reinforced concrete pipe, ranging in size from 48 to 120 inches in diameter.

Dry weather flow and a portion of wet weather flow collected by the Merrimack East Interceptor is combined with Merrimack West Interceptor and conveyed across the Merrimack River to the WWTF by a set of siphons (30-, 36-, and 48-inches in diameter) at the Merrimack CSO Station. Excess wet weather flow is diverted to the Merrimack River at this location.

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Barasford Interceptor (Wentworth/Douglas Trunk Sewer)

The Wentworth/Douglas Trunk Sewer begins in southeast Lowell along Wentworth Avenue and runs east along Douglas Road before turning in a northerly direction (zigzagging down some neighborhood street in the Belvidere neighborhood) to convey flow to the Barasford CSO Station.

The profile of this truck sewer is shown in Figure 2-13. The trunk sewer consists of approximately 10,200 linear feet of reinforced concrete pipe, ranging in size from 24 to 60 inches in diameter. The pipe conveys flow from the Wentworth Avenue and Douglas Road area in south Lowell across a topographic high point north to the Merrimack East Interceptor. This pipe is relatively flat (and deep at the high point). There are reporting surcharging problems at the upstream end of this interceptor.

Dry weather flow and a portion of wet weather flow are regulated by the Barasford CSO Station to the Merrimack East Interceptor. Excess wet weather flow is diverted to the Merrimack River at this location.

2.2.5 CSO Diversion Stations/Outfalls

There are nine CSO diversion stations that regulate wet weather flow within Lowell's interceptor system. During normal dry weather operations, wastewater flow is directed through the stations for conveyance downstream to the Duck Island WWTF for treatment before discharge to the Merrimack River. Wet weather flow in excess of the downstream conveyance capacity of the interceptor piping system is discharged as CSOs. Of the nine (9) CSO stations, seven (7) overflow to the Merrimack River, one (1) overflows to the Concord River, and one (1) discharges to Beaver Brook. Table 2-4 provides a summary of some key characteristics of the nine CSO diversion stations in Lowell. This table also shows the potential flow difference between the influent interceptor conveyance capacity and the downstream interceptor conveyance capacity.

Many of the diversion stations in Lowell are relatively sophisticated facilities, compared to collection systems in other New England cities that include screening equipment to remove large solids before flow enters downstream siphons, pumping equipment for discharge of CSOs when river levels are high, and large diameter diversion gates and discharge outfalls.

All the stations have multiple gates, with at least one diversion gate, as well as a flow control gate. Until recently, gates and pumps at the diversion stations were operated manually by personnel that were required to drive by vehicle to each station during rain events. Now, LRWWU utilizes a sophisticated system of instrumentation to provide real time control of the system including monitoring of flow depths and remote and automatic control of most of the CSO stations via local programmable logic controllers (PLCs) and the utility's Supervisory Control and Data Acquisition (SCADA) system. This equipment was installed as part of the Phase I LTCP.

With the exception of the First Street CSO Station, LRWWU has at least one depth metering device in each CSO station to monitor flows. With the exception of the First Street, Read Street, and Walker CSO Stations, the utility has the capability to automatically and remotely actuate flow control gates and pumps in each station from the Duck Island WWTF. This gate control system allows LRWWU to maximize the use of inline pipe storage in the interceptor upstream of each station, control flow to the downstream interceptor, and control the CSO discharges (either gravity or pumped discharge). Control gates at each station are referenced as the influent control gate – controlling the influent

Table 2-4

Summary of CSO Diversion Stations

Diversion Station	NPDES Outfall No.	Receiving Stream	Approx. Upstream Combined Acreage (acres)	Diversion Stations Station Influent: Influent Pipe Size (inches)	Influent Capacity (MGD)	Diversion Stations Station Effluent: Effluent Pipe Size (inches)	Effluent Capacity (MGD)	Potential Flow Constraint (MGD)	CSO Discharge Pipe Size (inches)	Downstream Connection
West/North Bank Interceptor										
Beaver Brook Station	007	Beaver Brook	570	96"	170	3 Siphons (16"+ 20"+ 24")	25	145	Pump Diversion (84") Gravity Diversion (Three 60" x 48")	West Interceptor
West Station	008	Merrimack River	1100 *(plus Dracut)*	96"+ 66"+ 48"	280	96"	93	187	Gravity Diversion (96" x 72")	Read Interceptor
Read Station	011	Merrimack River	175	60"	53	30"	16	37	Gravity Diversion (60")	Duck Island Interceptor
First Station	012	Merrimack River	90	48"	37	18"	3	34	Gravity Diversion (48")	WWTP
South Bank Interceptor										
Walker Station	002	Merrimack River	140	48"	32	3 Siphons (14"+ 16"+ 20")	8	24	Pump Diversion (54")	Beaver Brook Interceptor
Tilden Station	027	Merrimack River	350	72"	72	36"	28	44	Pump Diversion (42") Gravity Diversion (48")	Merrimack West Interceptor
Barasford Station	030(1)	Merrimack River	600	84"	277	48"	21	256	Gravity Diversion (84")	Merrimack East Interceptor
Merrimack Station	030(2)	Merrimack River	2,941	84" + 120"	204	3 Siphons (30"+ 36"+ 48")	63	141	Pump Diversion (48") Gravity Diversion (Four 48")	WWTP
Concord River Interceptor										
Warren Station	020	Concord River	1,626	90"+ 48"	348	3 Siphons (30"+ 30"+ 30")	45	303	Gravity Diversion (90")	South Bank Interceptor to Merrimack Station

Note: Potential constraints are the difference in capacity between the upstream and downstream piping systems at each diversion station.

interceptor depths, flow control gate – controlling flow to the downstream interceptor, diversion gates — which are opened to allow gravity discharge to the receiving waters. Pumped CSO discharges are typically automated based on the depth of the wet well after the flow is diverted into the wet well.

The gates are operated in unison to minimize CSO diversions when the gravity or pumped diversion gates are opened.

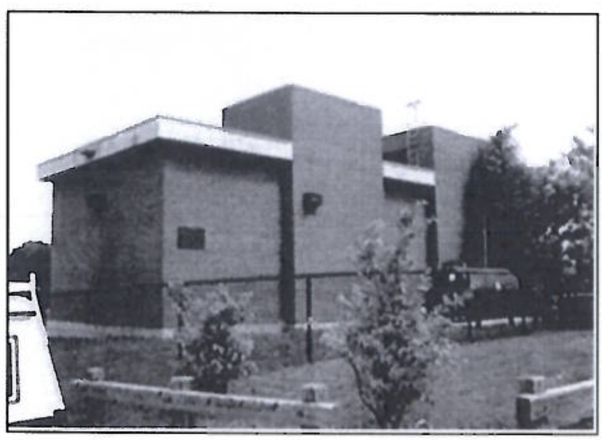
Most of the diversion stations were originally equipped with magnetic meters to measure flow through the station and CSO discharge. LRWWU has determined that most of these meters are not accurately measuring flow because of turbulent flow conditions. LRWWU utilizes the flow depth metering devices to measure/estimate CSO discharges via orifice equations or weir equations, depending on the type of discharge at each station.

The CSO stations are operated during wet weather conditions based on the High Flow Management Plan. Extensive gate and instrumentation improvements were completed at each of the stations during the Phase I LTCP program to improve the operations of the stations. This operations plan was extensively vetted during the Phase I LTCP program and maximizes treatment of wet weather flow at the Duck Island WWTF and inline interceptor storage before untreated CSOs are discharged from the Lowell system. The Phase I LTCP work is discussed in Section 3.

While remote control of the diversion stations has reduced CSO discharges, the benefits of these improvements are limited by the configuration of the interceptor system and diversion stations. The diversion stations create significant hydraulic restrictions in the interceptor system as they were designed for only dry weather flow plus a small amount of wet-weather flow through the downstream siphons. Four of the large diversion stations pass combined flow to a set of downstream siphons that convey flow under various rivers and brooks. Meanwhile, as shown in Table 2-4, very large diameter upstream interceptors convey high wet weather flow rates to these diversion stations. The result is downstream interceptor capacity that is typically only 20-30 percent of the upstream capacity. Thus the stations create "choke points" in the interceptor system at the siphons.

Although LRWWU operates the interceptor system and diversion stations to maximize the amount of flow that is conveyed to the Duck Island WWTF and minimize the amount of CSOs discharged to nearby streams, wet weather events can often necessitate CSO discharges before the WWTF wet weather treatment capacity is reached.

Walker Street CSO Diversion Structure



Walker CSO Station

This facility is located along the Merrimack River just upstream of Black Brook and the Pawtucket Dam. This station includes a building with below ground levels. Figure 2-14 shows a schematic drawing of the station layout. Flow from the Walker Interceptor conveyed to this station proceeds through mechanically cleaned bar screens before entering a diversion channel. Dry weather flow continues through a parshall flume and then into siphons crossing the Merrimack River to the Beaver Brook Interceptor. Wet weather flows in excess of the siphon capacity

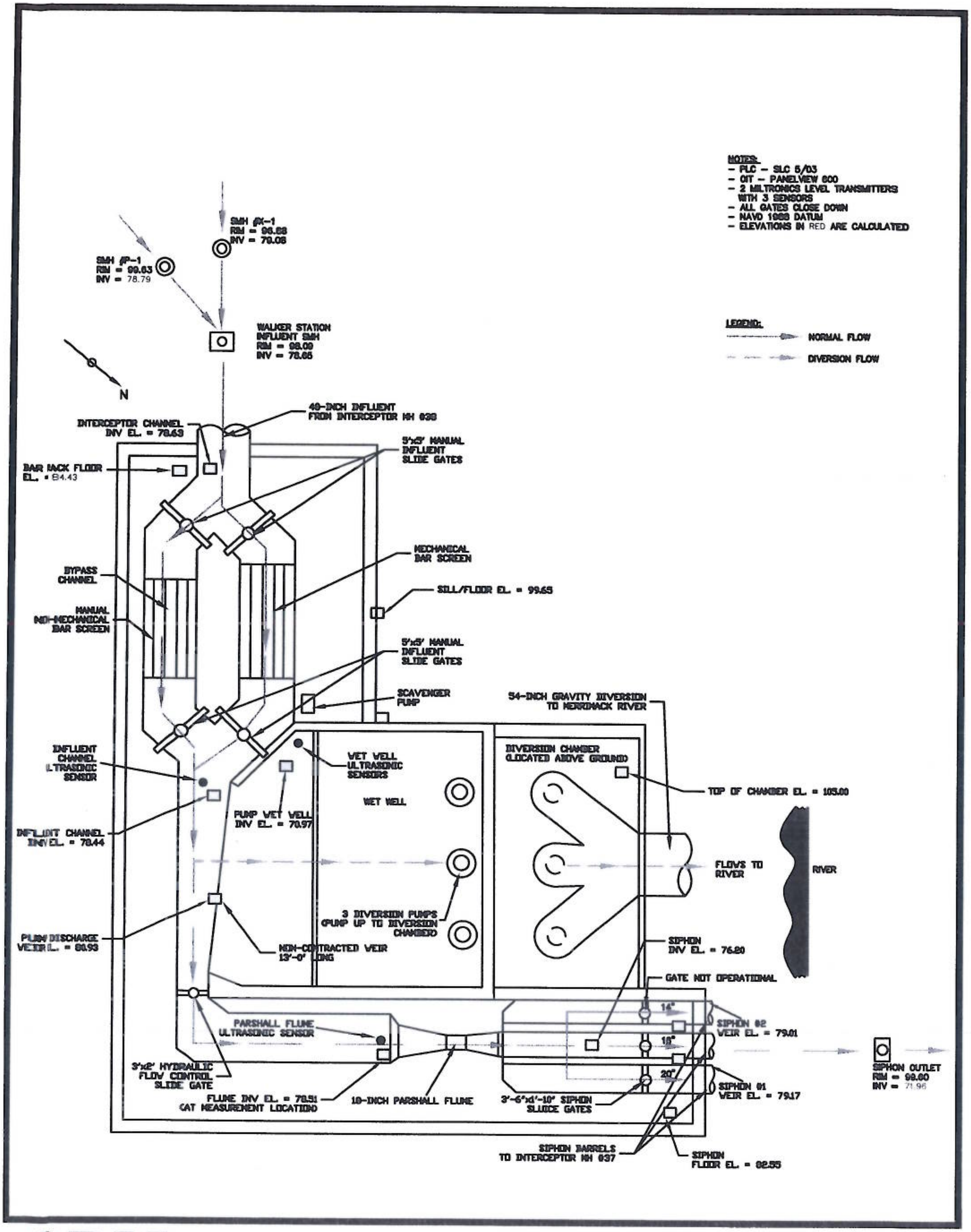


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Figure No. 2-14
WALKER CSO STATION
NOVEMBER 2013

Overtop a weir and drop into a wet well for pumped discharge to the river. The discharge pumps are activated automatically based on wet well level. The CSO discharge pumps have a capacity of 66 MGD. There is no gravity diversion at this structure because the interceptor is below the typical river water level (which is controlled by the adjacent dam).

The siphons have a reported maximum design capacity of about 8 MGD. Flow to the siphons was originally controlled automatically by flow control gate located at the end of the diversion channel. Automatic operation of this gate is now disconnected and the gate position remains constant for all storm events.

There are two existing ultrasonic depth measurement devices in the structure: one along the influent channel and one at the parshall flume.

Beaver Brook CSO Diversion Station

This facility is located along Beaver Brook at Martin Street and includes a building and below ground levels. Figure 2-15 shows schematic of the regulator station layout. All interceptor flow from the Beaver Brook Interceptor entering the station proceeds through mechanically cleaned bar racks and a diversion channel segment/chamber. The local PLC controls two influent gates and a flow control gate to minimize CSO discharges.

Beaver Brook CSO Station

Flow through the diversion channel is automatically controlled by a modulating sluice gate (flow control gate) at the end of the diversion channel segment. Typically, flow travels past the flow control gate to the parshall flume and to the downstream siphons and West Interceptor. The maximum capacity of the siphons is reportedly about 25 MGD.

The influent gates, located upstream of both bar screen channels, are operated based on depth of the influent sewer in unison with the flow control gate at the diversion channel. During storm events, the local PLC controls influent flow into the station using the influent gates, storing flow in the Beaver Brook Interceptor upstream, as necessary, to maximize flow conveyance downstream and avoid CSO discharges in the diversion channel. When the downstream siphon capacity is exceeded, the influent control gates are operated to maximize wet weather storage in the Beaver Interceptor, and when the upstream interceptor is at a depth of about 1 foot below the upstream interceptor pipe crown, CSO discharges (either gravity or pumped) are initiated at the diversion channel.

Wet weather flows in excess of the flow control gate setting are discharged over one of two weirs (at different elevations) in the diversion channel segment. A lower weir allows a gravity diversion to Beaver Brook. If receiving water levels are high, the gravity diversion gates are closed (manually). During wet weather when the gravity diversion gates are closed, combined sewage flow levels through the structure increase until a second weir is overtopped on the opposite side of the diversion channel. Flow overtopping this higher weir drops into a wet well where the flow is automatically pumped into Beaver Brook. The CSO pumped discharge capacity is about 117 MGD.

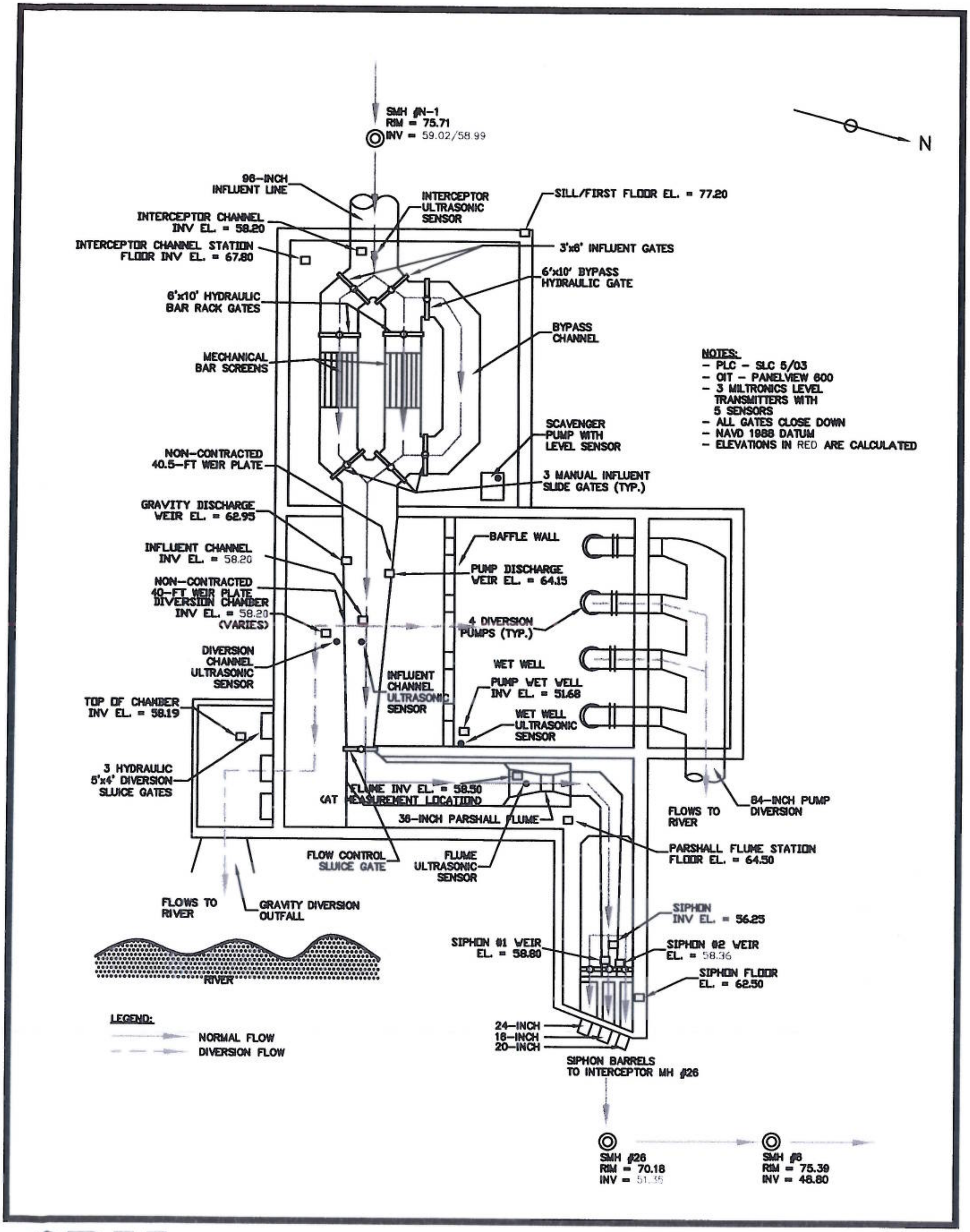

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Figure No. 2-15
BEAVER BROOK CSO STATION
NOVEMBER 2013

There are three existing ultrasonic depth measurement devices at this structure: two along the diversion channel (one for gravity diversion and one for pumped diversion) and one at the parshall flume (just upstream of the siphons) as shown Figure 2-15.

West CSO Diversion Station

This facility is located along VFW Highway and the Merrimack River in Centralville. Flow from the West Interceptor and flow from Centralville (including the Humphrey's Brook drainage area in Dracut) are conveyed to this facility. Figure 2-16 shows a schematic of the below grade station layout. A local PLC controls a single flow control gate and a single diversion gate.

Flow normally passes through the below ground control structure/vault and is conveyed downstream to the Read Interceptor and to the Duck Island WWTF. Flow is controlled by an 8-ft. x 8-ft. flow control sluice gate, which modulates to store flow upstream of the station in the West Interceptor and limits flow conveyed to the WWTF. This gate is programmed to modulate to maintain a high influent channel level so the upstream interceptor can provide storage up to about 1 foot below the pipe crown (not to exceed the local topographic low spots).

West CSO Station

When flows exceed the target West Interceptor levels, the CSO diversion gate is opened. The CSO diversion is a gravity discharge; when river levels are high, this diversion station is not used. There is a set of tideflex gates at the outfall to help prevent river water from coming into the system.

The Duck Island WWTF operators typically remotely operate the flow control gate to maximize flow to the treatment facility. Flow from the north bank interceptor system is controlled via the West CSO Station and south bank interceptor flows are controlled at the Merrimack CSO Station. The operators utilize system information to decide which station excess flow should be discharged from based on flow levels, river levels (Merrimack CSO Station has discharge pumps), and WWTF flow rates.

LRWWU has two depth monitoring devices at this station to measure upstream depths in the interceptor (for inline storage control) and to estimate CSO discharge flow to river.

The West diversion station is connected to an inoperable flood control pumping station (also shown in the figure). The pumping station was originally constructed by the U.S. Army Corps of Engineers (USACE) after significant river flooding in the city in the 1930s. The station was designed to discharge combined sewer flows from the Centralville area into the Merrimack River when river levels were high. In the mid-1970s, the station became inoperable from lack of maintenance. In addition, since that time, additional dams have been constructed along the Merrimack River, providing better flood

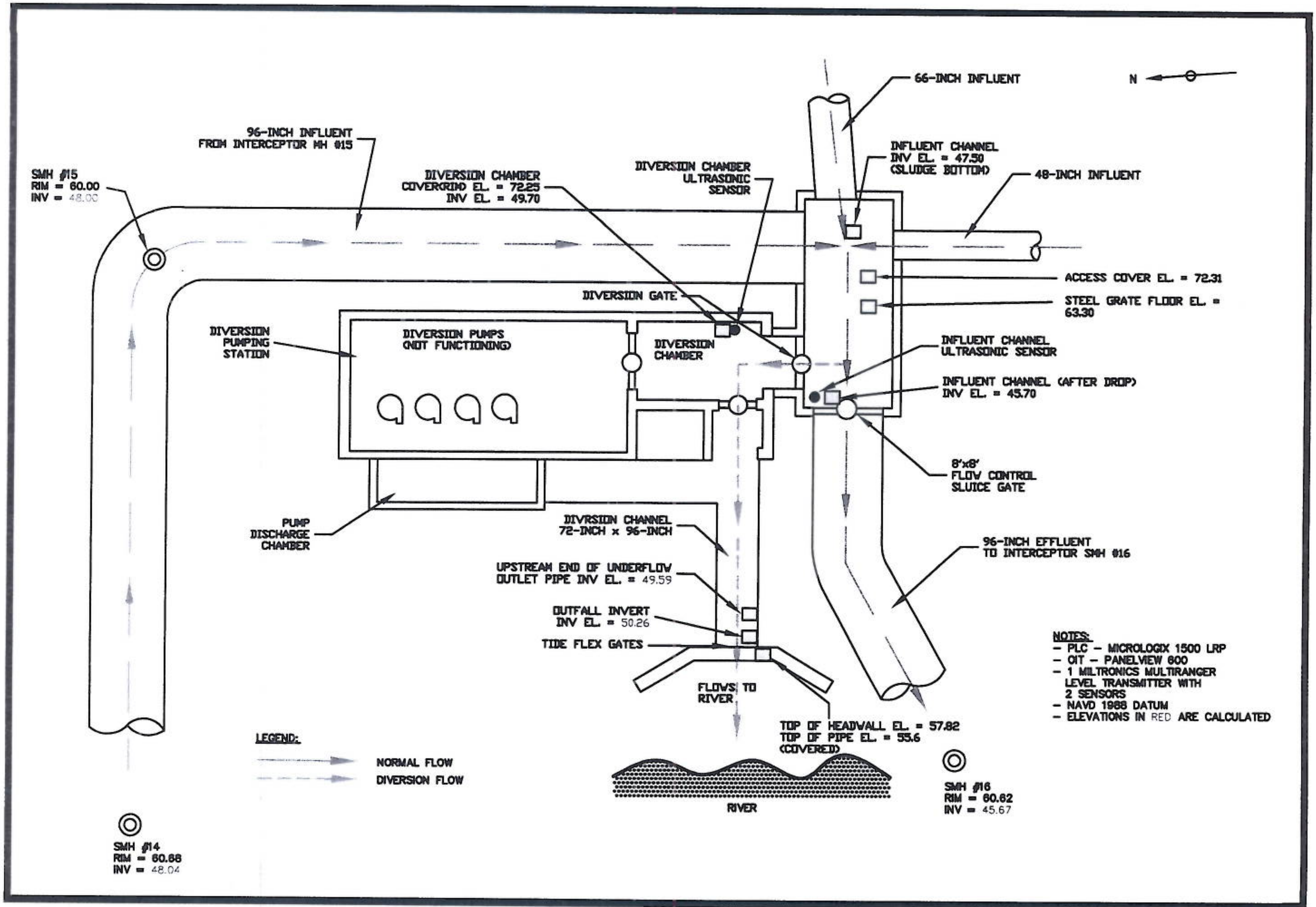

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Figure No. 2-16
WEST CSO STATION
NOVEMBER 2013

control and significantly reducing the need for this flood pumping station. The station building and below ground wet well still exist, but the pumps are no longer operable. The integrity of the superstructure is also in question.

LRWWU considered the potential to reconstruct or rehabilitate the existing flood control pumping station. The pump capacity at the site could be used to discharge CSOs when the river is high and as a flood control pumping station. However, the site is too constrained (with two-lane highways on either side of the station) to reconstruct the station to today's pumping standards with appropriate redundancy and standby power. Accordingly, LRWWU has been working with the USACE on a plan to relocate this flood pumping capacity to a new location at the Read Station site. LRWWU will utilize the capacity of the Read Interceptor to convey wet weather flow, which can't be discharged by gravity during high river levels, down to the Read Station site, where a new pumping station will be constructed. This future pumping station could be used as both a CSO discharge facility (when river levels are high) and to pump out the interior drainage from the Centralville area. This work will be incorporated into the next phase of LTCP work.

Read CSO Diversion Station

This station is a below-ground structure located along the Merrimack River near the rotary for the Hunts Halls Bridge. Figure 2-17 shows a schematic drawing of the regulator station layout. There is no automatic or remote operation of this station during wet weather conditions and there are no pumps to discharge flow when the river is high.

Dry weather flow typically passes through the structure via a manually operated flow control gate and 30-inch diameter dry weather connection pipe to the interceptor. Diversions occur when the influent level rises above a weir in the outlet chamber. CSO flow discharges to the Merrimack River via a 60-inch diameter outfall pipe. A tide-flex valve is installed at the end of the outfall to restrict river water from entering the system during high river levels. This station reportedly only diverts very infrequently under large and intense storms.

Read CSO Station

There is one depth monitoring devices in this structure in the influent channel, which is used to monitor the depth of flow into the structure and is used to estimate flow over the CSO diversion weir in the adjacent chamber. The monitoring device at the weir can also indicate if river water is leaking back into the system during dry weather (although this has never occurred).

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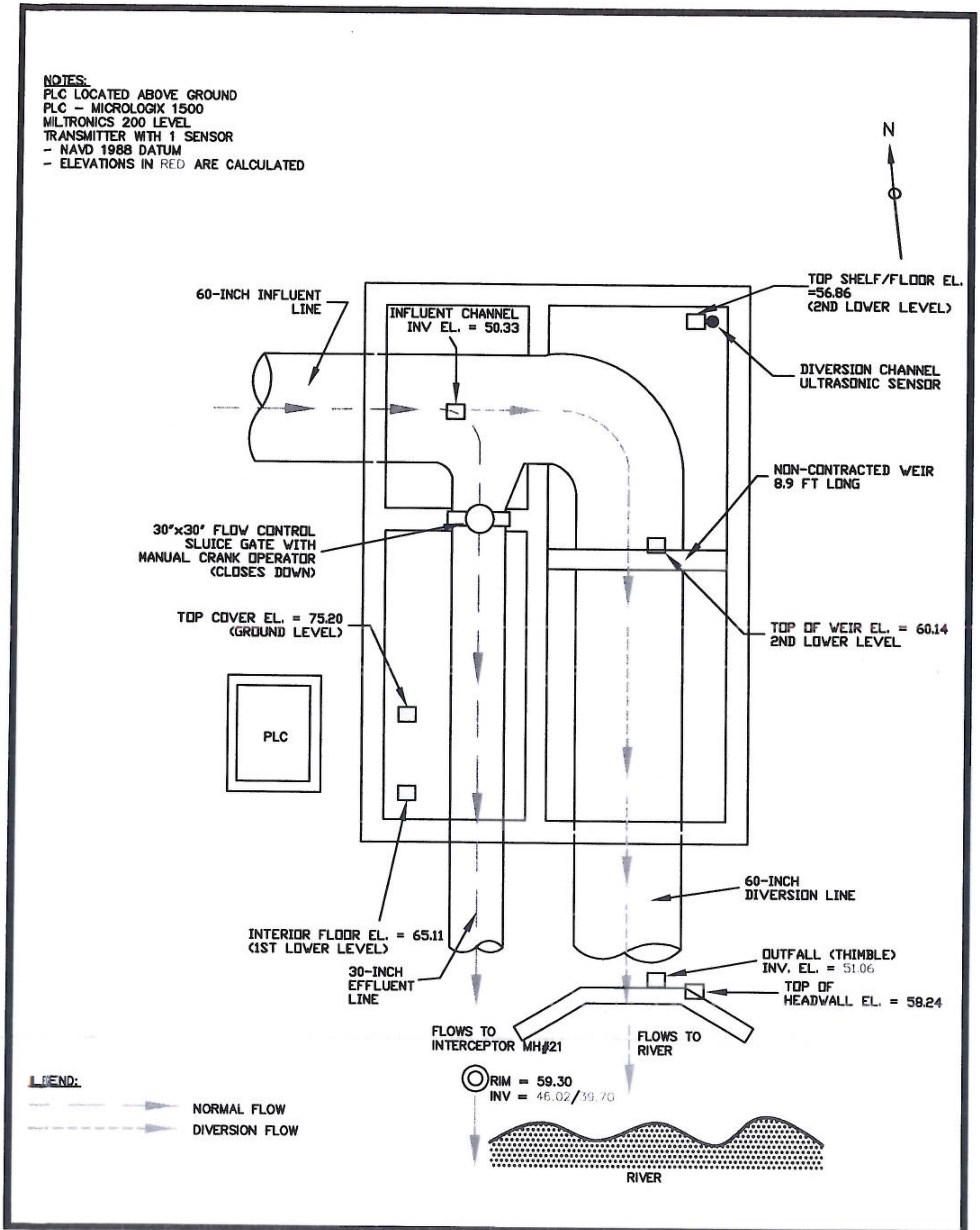
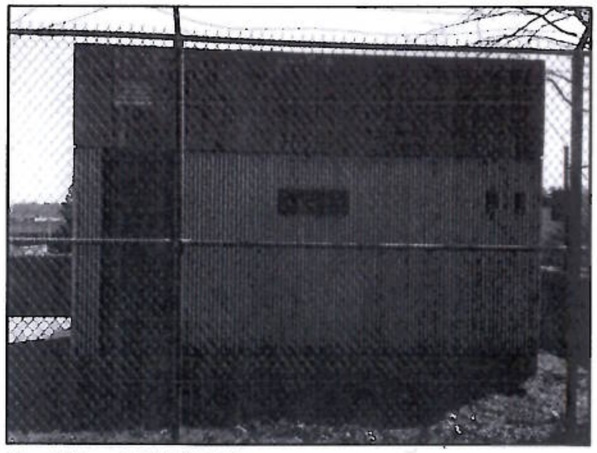


Figure No. 2-17
READ CSO STATION
NOVEMBER 2013

First Street Diversion Structure

This facility is located across First Street from the WWTF and includes both a superstructure and below ground levels. Figure 2-18 shows a schematic drawing of the layout. Dry weather flow from a small area in northeast Lowell passes through a parshall flume and a manually cleaned bar rack to a direct pipe connection to the WWTF. Wet weather flow can be manually diverted to the outfall by opening the outfall sluice gate.



First Street CSO Station

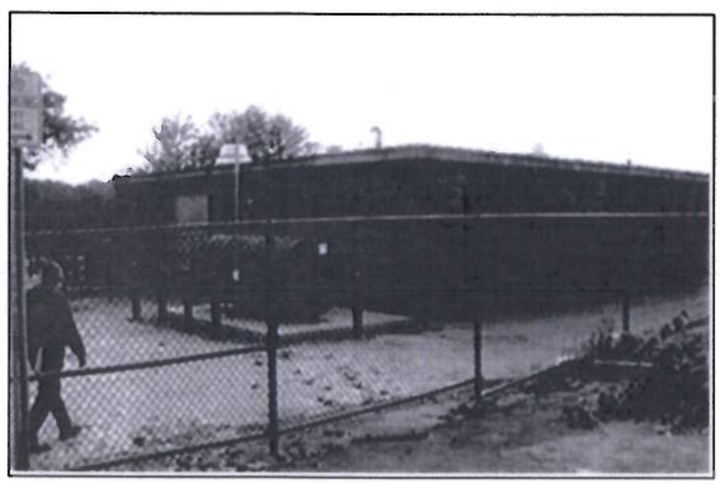
Originally, this station was designed and constructed to receive flow from Dracut in addition to a small amount of combined flow from the sub-area adjacent to the WWTF. Flow from Dracut was subsequently connected to the Lowell system by another route. Accordingly, flow through the station is small and LRWWU does not operate this CSO diversion.

During significant storm events, there is the possibility that surcharged flows can cross over the basement floor of the structure and pass through an access grate and ultimately get discharged through the CSO outfall. Although this condition has happened before, recent inspections of the station show no evidence of surcharging on the floor of the station; so it is assumed that no discharges have occurred from this structure for some time.

Tilden CSO Diversion Station

This facility is located along the Merrimack River near the Tsongas Arena and includes a building and below ground levels. Figure 2-19 shows a schematic drawing of the regulator station layout. Flow enters the station via a 72-inch pipe (Upper Tilden Interceptor). Dry weather flow continues through a parshall flume and then exits the station to the Lower Tilden Interceptor (a 36-inch pipe).

Wet weather flow in excess of downstream interceptor capacity is discharged to the Merrimack River via a gravity diversion or, when river levels are high, a pumped diversion. The CSO pumps have a capacity of 72 MGD. Two diversion gates, a flow control gate, and two diversion pumps are operated by the local PLC or remotely via SCADA from the WWTF. The flow control gate is operated based on upstream interceptor depth to store flow within the Upper Tilden Interceptor and maximize downstream conveyance to the Lower Tilden Interceptor (based on parshall flume flow). When flows exceed downstream flow and upstream storage capacity, the gravity diversion gate is opened. The gravity diversion gate is then modulated, working with the modulating flow control gate, to store flow within the interceptor, to minimize CSO discharges.



Tilden CSO Station

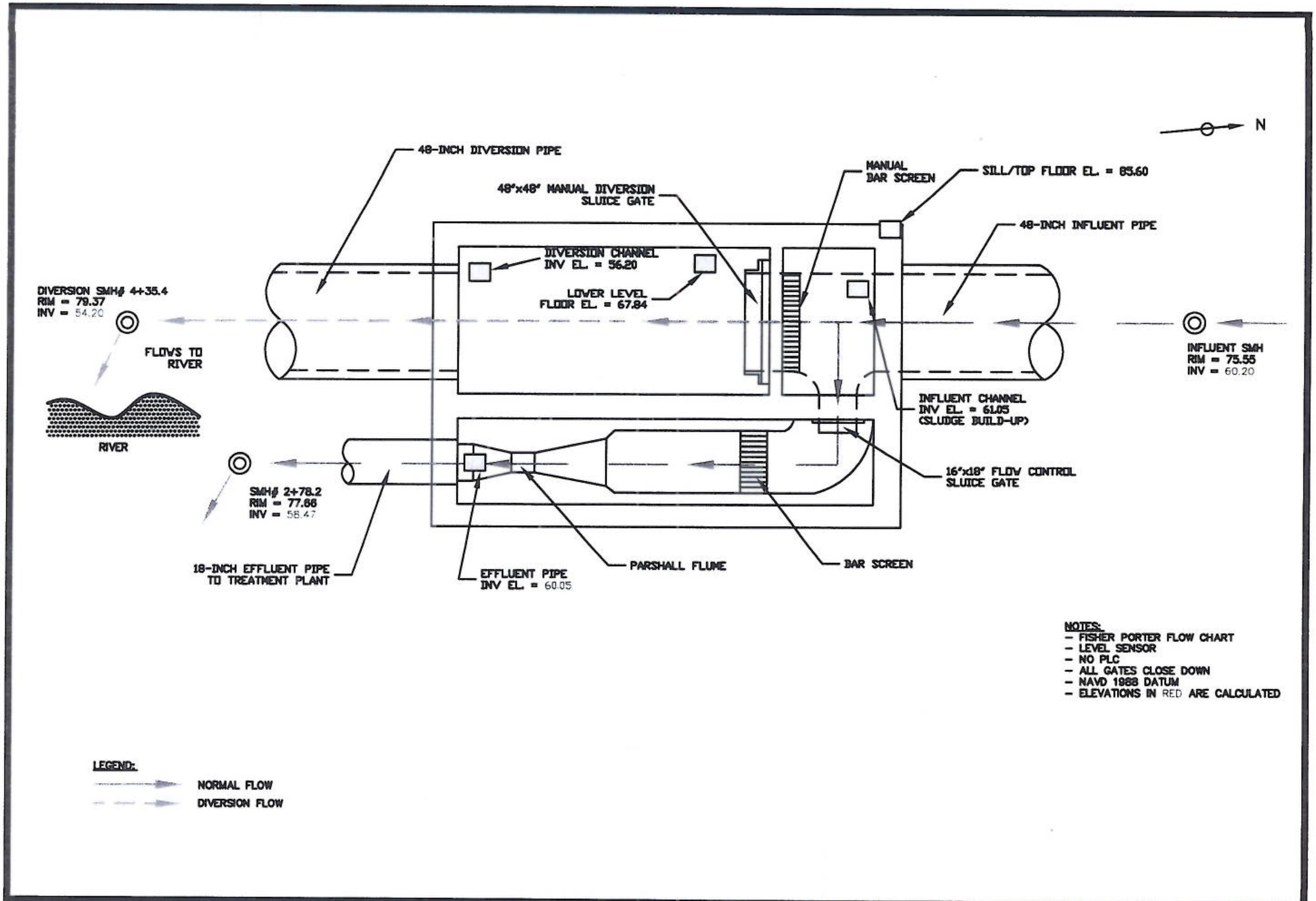


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Figure No. 2-18
FIRST CSO STATION
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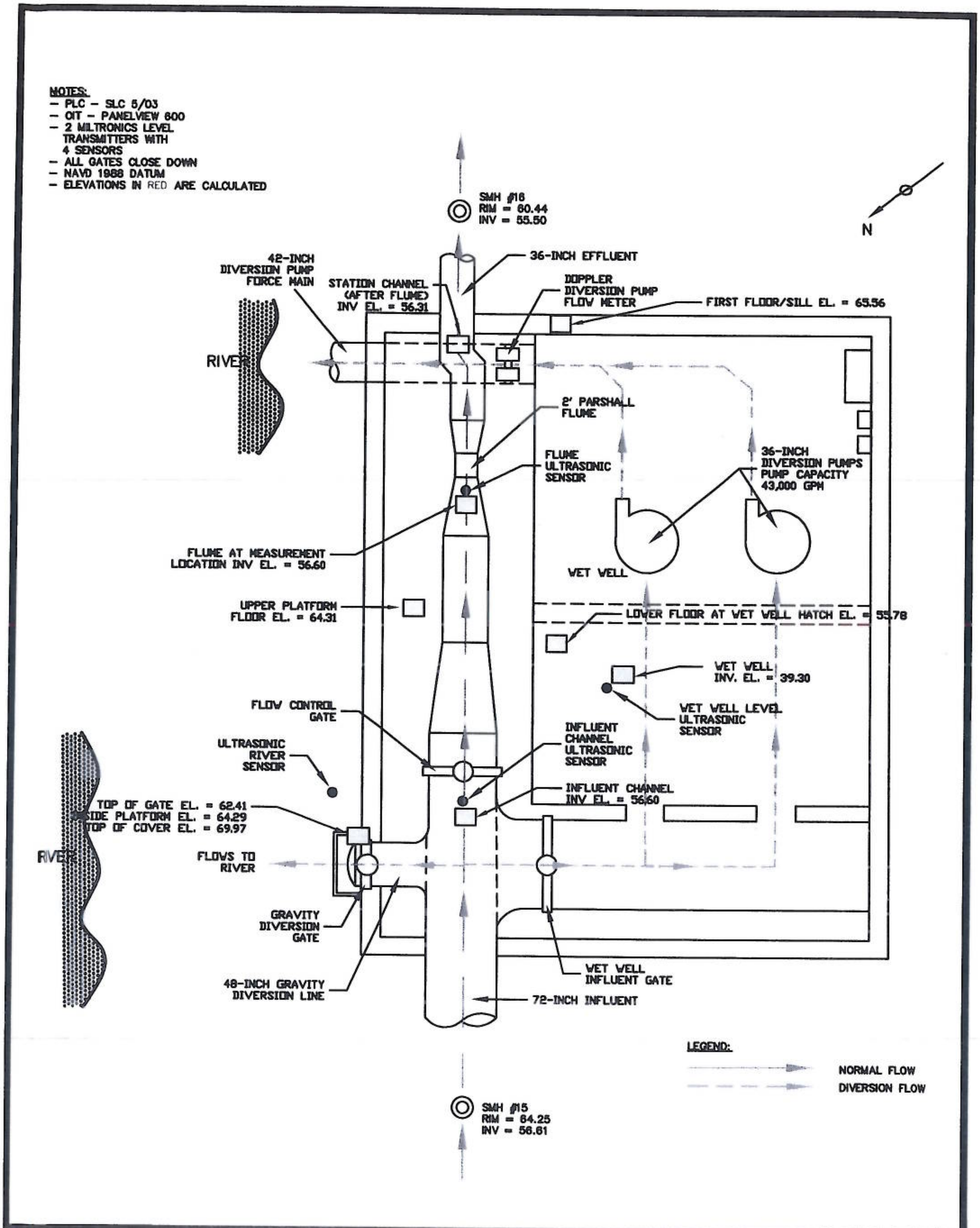

Figure No. 2-19
TILDEN CSO STATION
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